# Sustainable Renovation of Buildings – A Model Applicable to China?

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***Abstract*—The paper contrasts the situation of the built environment and its evolution in Europe and in China, discusses the principles of and the need in both Europe and in China for sustainable renovation, before elaborating on the challenges for the future in terms of how to overcome barriers to sustainable renovation, both globally and in China**

***Keywords*—Sustainable renovation, built environment, Europe, China, challenges to overcome**

## I. INTRODUCTION

The built environment is one of the most obvious examples of the impact of human activity. Globally, buildings have a substantial impact on our energy use and the pollution of our environment. Buildings consume 35-40% of our primary energy, 30-40% of all raw materials used, 15-20% of all water used, and 10% of land use. A staggering 3 billion tons of raw materials are used worldwide for building activities annually [1]. Buildings also have a high share in pollution emissions and an adverse impact on our environment. Buildings account for 35-40% of all greenhouse gas emissions, 30-35% of all solid waste generation, and about 20% of water effluents [2].

Governments around the world are starting to define requirements for sustainable buildings [3]. Targets are being set for reductions in energy consumption and carbon dioxide emissions. The Chinese government has committed itself to ambitious targets to improve energy efficiency. In its 11th Five-Year Plan for National Economic and Social Development (2006-2010), the Chinese government set the target to decrease energy consumption per unit of GDP by 20 percent [4].

## II. CONTRASTING SITUATIONS IN CHINA AND IN EUROPE

Building construction in China poses tremendous opportunities, but also grave challenges. Today, existing buildings in China represent a total floor space of about 40 billion m2. New construction is proceeding at the amazing rate of 2 billion m2 per year. China is building the equivalent of a new Shanghai every year! Over the next 15 years, another 20 billion m2 floor space will be added. According to information provided by the World Bank, by 2015, half of the world's construction will take place in China [5]. The World Bank also notes that by that time, about half of the building stock in China (both residential and commercial) will have been constructed after the year 2000. Until 2025, China is expected to build the equivalent of the entire U.S. building stock! Already today, nearly half the new floor space built in the world every year is built in China. All of this is good news, since this means that any energy conservation measure taken now in China on new building construction will have a strong influence on global energy consumption and carbon dioxide emission already by 2015! The good news is that by 2015, half of all the buildings in China will be less than 15 years old. The bad news, however, is that the energy standards for these new-builds are low – four times more energy is required per m2 for heating and cooling in China compared to Europe [6]. Efforts in China are underway to highlight the need for more sustainable building technology. However, one of the key challenges in the coming years, besides the establishment of stricter building codes with regard to energy-efficiency, will be the refurbishment of existing buildings in order to reach the demanding climatic goals of the government.

Contrast this to the situation in Europe, which is almost diametrically opposed to the one in China, at least with regard to the new building activity. There is a stock of 160 million buildings (corresponding to 21 billion m2) in the European Union (EU). Existing buildings are replaced at a very low rate;

the present rate of construction of new buildings is below 2%/year in all major European countries. For the whole of the EU, the annual production of new buildings is 1%, demolition rate about 0.5%, and retrofit about 1.8% [7].

These figures push the hope of having a truly energy-efficient built environment far beyond one century and probably closer to two centuries if action is limited to new buildings. For that reason focus is needed on the renovation of existing buildings. Already now the number of buildings that are renovated each year exceeds the number of new buildings in Europe. Growing renovation rates mean that improvements in technologies and processes are needed to meet the market demands. Improving the thermal performance of the building envelope by renovating and insulating the exterior walls and by installing modern, high-performance insulating windows is a great place to start; however, the overall goal of sustainable renovation can only be attained by considering the wider scope of environmental, social, cultural, economic and institutional aspects. In this context, the term "sustainable renovation" has been coined.

## III. LEGISLATIVE ENVIRONMENT SETS THE CHALLENGE FOR THE EUROPEAN BUILDING INDUSTRY

The Directive on Energy Performance in Buildings (EPBD), which was adopted in 2002, came into force in January 2003, and had to be implemented by the EU Member States at the latest on 4 January 2006, is the main legislative instrument affecting energy use and efficiency in the building sector in the EU. The Directive tackles both new build and the existing housing stock and requires all 27 EU countries plus Norway and Switzerland to update their national Building Codes on a regular basis [8]. Most of the activities associated with improving the energy performance of buildings are associated with negative greenhouse gas (GHG) abatement costs, both for residential and commercial buildings; thus, essentially, they come for free (considering the energy savings over the life-time of the building) [9]. One of the four key elements described in the Directive is the introduction of energy certificates for the existing building stock. The EPBD recast was intended to overcome some of the weaknesses of the previous 2002 Directive by including the additional requirements [10]. For many member states, the requirement for updates every five years means that they will revise their Building Codes again in 2010 or 2011.

Having recognized the social and economic impacts of energy savings in construction, the sector is fully aware today of being confronted by a huge responsibility. Already in March 2007, the European Council has set clear goals for 2020: Reduction of 20% of the total energy consumption; 20% contribution of renewable energies to total energy production; 20% reduction of greenhouse gases (GHG) below 1990 emissions (so-called 20-20-20 goal) [10]. With the increased focus on the energy performance of the existing building stock, these new regulations are expected to contribute to triggering a renovation boom with the associated broad range of financing models and technology solutions. The buzzword that is increasingly used in the EU in this context is "sustainable renovation".

## IV. SUSTAINABLE RENOVATION

"Sustainable renovation" may be defined as the environmentally responsible improvement of the quality of the built environment, closely linked with needs expressed by the actors concerned(users), especially with regards to improvements in comfort and reductions of cost-in-use and of maintenance of buildings (energy economies, reduced water consumption, optimization of raw materials). The aim is to achieve:

- A healthier building, which has demonstrated reduced absenteeism
- An improvement of living or use conditions
- Increasing flexibility of the whole building concept and its parts, according to the current and future needs of inhabitants;

Obviously, key elements in the sustainable renovation are the focus on renovation rather than the demolition of existing buildings; the decrease in energy use and in related building operational expenses; the increased use of environment-friendly materials and renewable energy sources; and economically favorable and innovative planning, building and using measures.

While the concept of sustainable renovation was initially primarily applied to residential buildings, it is now increasingly used in commercial and especially public buildings. In the European Union, the public authorities that own or occupy an existing building are expected to lead by example when having major renovations conducted on the building.

The expected outcomes from the sustainable renovation of public buildings are energy savings, increase of comfort, healthy working environment, extension of building life cycle, economized exploitation, and environmental protection [12]. As already mentioned before, sustainable architecture is more than just energy efficient buildings. However, energy efficiency is the most important measure that allows addressing the three current issues: environmental damage, climate change and energy security. The energy used in existing buildings is easy to measure and it can be shown that the vast majority of energy consumption occurs during the operation of the building, with operation energy accounting for over 80% of total energy consumption [13].

Operational energy reduction is a key priority, since the "most sustainable energy is energy saved". Energy itself is not of particular interest, but rather is a means towards desired ends. Clients desire the services that energy can deliver, for instance, comfort, illumination, power, transportation - not energy by itself. Hence, maximum energy efficiency with minimal environmental impact is the architectural challenge that ultimately allows us to have our cake and eat it. In this context, material choices that impact operational energy are important, while they are less significant for the energy spent in manufacturing, construction and demolition of the building.

Therefore, two of the key objectives in designing sustainable buildings are to lower the operational energy consumption and the life-cycle costs of the building. This should be achieved by first focusing on improving the performance of the building envelope in order to lower the energy demand, as the life span of the envelope is between 50 and 100 years [14].

Common-sense dictates to focus on issues such as air tightness of the building envelope, the quality of the insulation and especially of the windows, and to avoid thermal bridges. The second priority then should be to avoid energy use, for instance, by using efficient appliances and through the increased use of day-lighting. Once this has been accomplished, then the focus should shift towards the generation of renewable energy from suitable sources (PV, wind turbines, etc.), as the life span of these systems is in the 10-25 years range [15]. This approach is also dictated by simple economic considerations, as more capital is needed for an oversized renewable energy system to compensate for a poorly designed building envelope or for inefficient appliances.

## V. CHALLENGES FOR THE FUTURE: HOW TO OVERCOME BARRIERS, BOTH GLOBALLY AND IN CHINA

Commercial and administrative building owners are anxiously trying to find ways to lower their energy expenditures and are realizing that conserving energy by using innovative technologies can reduce energy consumption by 20 to 30 percent. So why are they not rushing to retrofit their buildings if it means saving money, improving employee comfort and property values, not to mention saving the planet? The reason lies in the inconvenient truth that they would need to spend money in order to save money. The economic drivers and suitable ROI models are proven and the technology exists that makes buildings, even older ones, operate more intelligently, but the call to action needs a boost from the government. For many building owners capital costs are the barrier to investing in building retrofits and without incentives, large-scale adoption of energy saving retrofits will be a challenge.

There are also challenges specific to China: Many energy savings initiatives can be achieved with little or no cost through improved building design and good management practices. However, there are substantial market barriers that need to be overcome to achieve energy efficiency and low- cost carbon mitigation potential. These barriers include: the high cost of gathering reliable information on energy efficiency measures; a lack of proper incentives for property developers, builders and landlords who would pay for efficiency costs; limitations in access to financing; and subsidies on energy prices (for

instance, space heating in China's northern cities is billed on the basis of one's area rather than actual consumption, and household electricity costs are heavily subsidized by local governments). Progress on energy efficiency depends on people in the building industry being aware of the importance of the issue – and being willing and able to act on it [16].

Appropriate policy instruments are required to help implement energy efficiency in buildings. Apart from the regulatory approach (such as mandatory minimum efficiency requirements in building codes), flexible market-oriented approaches like certificates and labeling, energy performance contracting, tax and fiscal instruments need to be developed further to achieve greater energy savings in buildings in China. The international financing alternative presented by the Clean Development Mechanism in the framework of the Kyoto Protocol may offer a new opportunity in filling the investment gap for building energy efficiency.

The building sector is hard to move. Much remains to be done to achieve a more sustainable built environment. Sustainable renovation of the existing building stock will be a key element in achieving our goals of limiting global warming.

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